sexes would in all probability be gravely imperilled, and the State would almost certainly have to intervene. Again, while Mr. Wells is doubtless within his rights in scoffing at the racial prejudices of the time, in his scorn of popular notions of "superior" races, "including such types as the Sussex farm labourer, the Bowery tough, the London hooligan, and the Paris apache," and in his contention that "no race is so superior as to be trusted with human charges," his anticipation of wholesale racial fusions seems to involve a serious underestimate of the æsthetic instincts. Lastly, although Mr. Wells has keenly perceived the spiritual value of a temporary retreat from society, it may be doubted whether he does not purchase its advantages at too high a cost. The solitary voyages of his Samurai would assuredly lead to a high death-rate among them, and though one type of mind was thereby strengthened, another would be unhinged. The rule, in short, seems too rigid for the variety, and too cramping for the freedom, of man, both of which Mr. Wells is elsewhere anxious to appreciate. But Mr. Wells, on the whole, shows a wisdom far superior to that of former Utopists in not seeking to construct out of the imperfect materials which alone the actual can furnish a static order which shall be, and if possible remain eternally, perfect. He aims rather at laying down the principles of an order which shall be capable of progressively growing towards perfection; and so it may well be that in his ideal society men will be less reluctant than now to learn from experience.

F. C. S. S.

THERMODYNAMICS.

Thermodynamik. By Dr. W. Voigt. Vol. ii. Pp. xii+370. (Sammulung Schubert, xlviii.) (Leipzig: G. J. Göschen, 1904.)

Diagrammes et Surfaces thermodynamiques. By J. W. Gibbs. Translated by G. Ray, of Dijon, with an introduction by B. Brunhes, of Clermont. Pp. 86. (Paris: Gauthier-Villars, 1903.)

THE second volume of "Thermodynamik" deals essentially with applications. It is divided into two parts, devoted to thermochemical changes and thermoelectric changes respectively. Under the first heading are included changes of phase of a single substance, which occupy the first 168 pages. In this connection we have sections dealing with Van der Waals's formula, steam and gas engines, the equilibrium of an atmosphere of water vapour, and the Hertzian adiabatics. The next chapter deals with phases formed of more than one component, the properties of binary mixtures occupying about 80 pages, and those of a system with more than two components being treated subsequently. The part dealing with thermoelectric changes contains a good bit of introductory matter on electrostatics. In the third chapter of this part the properties of black-body radiation are discussed at much length.

The subject of thermodynamics can be defined in various ways. In its most restricted sense it deals exclusively with the first and second laws and direct deductions from them, in just the same way that dynamics deals with direct deductions from the laws of motion. But the name thermodynamics is often used to include all phenomena directly or indirectly associated with heat, and it is in a fairly broad sense in this respect that Dr. Voigt deals with the subject. A good many of the formulæ are based more or less on experiment or reasoning not directly connected with the two laws of thermodynamics. Thus, for example, in the chapter on radiation the only piece of work which can be regarded as thermodynamical in the narrower interpretation is the proof of the equation by which Stefan's law is deduced from the formulæ for radiation pressure. But in addition to this we have here a general discussion of radiation based on electrodynamical considerations, Wien's law, Planck's law of mixture, and Kirchhoff's theorem. The relation between the black radiation and wave-length is in no way deducible directly from the first and second laws.

These examples may be taken as affording some indication of the extended scope of the book. Passing to matters of detail, the author is to be congratulated on the lucid way in which he clears up many points usually regarded as obscure. We may instance the detailed discussion of the thermodynamical potential of a gas-mixture (§ 69), a point which receives scanty attention in many books we have seen. The author's task is made easier by the fact that most of the higher applications of thermodynamics deal with *equilibrium*. Now, whether we deduce the conditions of equilibrium from making the available energy a minimum, the entropy a maximum, or by any other equivalent hypothesis, the variation of the function selected must in general vanish to the first order, so that the conditions of thermodynamic equilibrium (apart from stability) are deducible from the equations of *reversible* thermodynamics. Very little is said in this book about irreversible phenomena, and this is perhaps fortunate owing to the great difficulty of dealing with these phenomena in a clear and logical way. The kind of impression which a beginner is likely to form in reading about irreversible thermodynamics may be exemplified by the following three apparently contradictory statements:—"The increase of entropy is dQ/T." "The entropy of the universe tends to a maximum." "For a cyclic irreversible cycle $\int dQ/T<0$."

It would be hardly an exaggeration to assert that whether any statement in irreversible thermodynamics is right or wrong depends entirely on the way of looking at it. For example, in § 105 a very little is said about irreversible electric phenomena, which is doubtless correct according to the author's interpretation; but whether this is the best way of stating the case is necessarily a matter of opinion.

In connection with the continuity of the liquid and gaseous states, the rule for the horizontal line in the isothermal diagram is deduced from van der Waals's equation (p. 151), and is not treated as a general result. In this method, however, the significance of the rule is somewhat lost. The proper condition that the rule may hold good is that the liquid and gaseous

states should be connected up in the (p,v) plane by a system of curves T = constant, consistent with the differential equation

$$\frac{dy_v}{dv} = T\frac{d^2p}{dT^2},$$

and making y_v equal to the specific heat at constant volume in the regions which represent physically possible states. For the validity of the rule it does not matter how the curves are joined up provided that the above differential equation is everywhere satisfied.

The notation may appear somewhat cumbersome, but anyone who tries to express thermodynamical formulæ in writing will find it impossible to do so clearly and precisely without some such large array of symbols. In particular, the use of capital letters for the volume, entropy, energy, and other thermodynamic magnitudes of a whole body, and small letters for the corresponding magnitudes per unit mass, is a very useful convention. The different forms of d, δ used for differentiations, variations, and diminutions are less easy to follow. If we attempt to compare the subject of this volume with Prof. Planck's excellent little treatise, we shall probably come to the conclusion that Prof. Voigt goes more into elaborate details, while Prof. Planck keeps more to the main points. The book now before us thus contains the more information about a wide range of physical phenomena, but Prof. Planck's book is the easier to read. Neither book can be said to be better or worse than the other, as each has its own uses.

The French translation, which forms No. 22 of the physico-mathematical series appearing under the title of *Scientia,* contains the two papers "Graphic Methods in the Thermodynamics of Fluids" and "A Method of Geometric Representation of the Thermodynamic Properties of Substances by Means of Surfaces," both originally published in the Connecticut Transactions for 1873. It is accompanied by a short notice of Gibbs's life and works, and an introduction by Prof. Brunhes. The latter, giving as it does a general and explanatory account of the subject-matter of the papers translated, forms a useful addition to the book.

G. H. B.

FUNGUS-GALLS.

Beiträge zur physiologischen Anatomie der Pilzgallen. By Hermann Ritter von Guttenberg. Pp. 70; with 4 plates. (Leipzig: Wilhelm Engelmann, 1905.) Price 2s. 9d. net.

THE study of galls is never more profitably approached than when the mutual inter-reactions between parasite and host-plant are considered conjointly. The intimate connection existing between these two, whether the parasite be insect or fungus, forbids the divorce of either party, and it is therefore a pleasure to come across a work in which this close union is recognised, and an endeavour made to explain the anatomical changes occurring in fungus-galls from a physiological standpoint.

In this work the effects caused by five different fungi on as many host-plants are described. The fungi all belong to separate families, as also do the hosts, and the series is therefore admirably suited for generalising the results. It includes Albugo on Capsella, Exoascus on Alnus, Ustilago on Maize, Puccinia on Adoxa (where, however, no gall-formation arises), and Exobasidium on Rhododendron.

The constancy of form and complexity of structure, characteristic of many insect-galls, are not found here, and the principal changes observable may be briefly summarised as consisting of the hypertrophied development of a large-celled, thin-walled parenchymatous tissue containing very vacuolated protoplasm, enlarged nuclei, and rich stores of starch or water. This is accompanied by an increase in the number of vascular bundles, or at least of their elements, and by modifications of the epidermis, whilst the assimilatory and aërating systems generally tend to be suppressed.

These anatomical changes are, in the author's opinion, mostly due to a change of function which the tissues assume under the influence and for the exclusive benefit of the parasite. The fungus may almost be regarded as a sculptor working with clay. It moulds the host-plant at will, forcing it to lay down a store house and fill it with food for the tenant's use, forcing the xylem to predominate when water is needed, or the phloëm when carbohydrates are required. Where spore formation is proceeding, accessory bundles are laid down to provide the increased supplies necessary. Here the epidermis is weakened so as not to hinder the dispersal of spores, there the mechanical tissue suppressed lest the progress of the fungus be impeded, while even the chlorophyll granules, when present, work in the service of the parasite. Everywhere the story reads as if the host had become wholly subservient to the will of the parasite; but were the author now to exchange his brief and act as counsel for the host, he might equally well explain many of the changes as evidencing an intense effort put forth by the latter to overcome the former. A final summing up would then be less partial, and productive of still more valuable results.

Here and there the author *has* observed indications of this struggle, and one point to which he directs attention is of special interest, viz. the deposit of a cellulose cap or sheath around the invading haustorium or hypha, apparently for the purpose of preventing its entry. This phenomenon, which, though of frequent occurrence, is not generally known, is most remarkable in *Ustilago Maydis,* where the whole length of an intracellular hypha in its passage through a cell may become enclosed in a cellulose tube. Subsequently this tube may become irregularly thickened in parts, and then shows distinct stratification.

The observations regarding the behaviour of the nucleus—its lobed appearance, occasionally leading on to amitotic division, its participation in the formation of the above mentioned cellulose sheath, its subsequent decrease in size, the aggregation of the chromatin at the periphery, &c.—are all most interesting. Some of them need confirmation by more exact histological methods than the author seems to have employed, before his conclusions can be accepted, *e.g.*